Techniques for Radiofrequency Ablation of Head and Neck Tumors

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Objectives: To describe the various techniques that have been developed for application of radiofrequency ablation in the palliative treatment of recurrent and advanced head and neck malignant tumors.

Design: Case series with a follow-up of 3 to 18 months.

Setting: Faculty practice, research protocol, tertiary care academic medical center.

Patients: Fifteen treatments were administered over a 3-year period to 12 patients with advanced and/or recurrent tumors. Eleven tumors were squamous cell carcinomas of the oral cavity, oropharynx, and maxillary sinus, and 1 tumor was a medullary thyroid carcinoma. Three of the 12 patients were treated on 2 separate occasions. Patients were selected as a referred sample and sent specifically for treatment with radiofrequency ablation because they were not candidates for the standard curative options of radiation or surgery. No patient refused enrollment, nor were any patients withdrawn because of adverse events.

Intervention: Radiofrequency ablation is a method of localized hyperthermia resulting in tissue necrosis. Ninety to 150 W of energy is applied, achieving intratumoral temperatures of 60 to 110°C for 5 to 15 minutes per ablation. Techniques have been developed to apply radiofrequency ablation under direct vision, endoscopically, percutaneously, and with ultrasound and computed tomographic guidance.

Results: The radiofrequency ablation probe was accurately placed and treatment administered on 15 occasions. No perioperative deaths occurred. One patient suffered a stroke. Subjective patient improvement was reported with regard to pain (n=9), appearance (n=3), and function (n=4).

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Radiofrequency ablation (RFA) is an emerging treatment modality for the destruction of malignant tumors.1 Over the last 10 years, RFA has been increasingly used to treat metastatic liver tumors in a similar manner to cryotherapy, by insertion directly into the tumor, but with greater ease of application and fewer complications.2 In the last 2 years, reports have surfaced of the application of RFA to various other tumor sites, including the prostate,3 kidneys,4 breasts,5 spleen,6 thyroid,7 and tongue.8

Radiofrequency ablation is applied by inserting a metal needle probe (Figure 1) into a tumor. Several tines are then advanced from within the needle deeper into the tumor; half of the tines are active electrodes and half are thermocouples that monitor the temperature and impedance between the active tines. The electrodes transmit alternating current that creates intracellular ionic agitation within the adjacent tissues, thereby producing intratumoral hyperthermia and subsequent tumor necrosis. A recent study of breast tumors excised immediately after RFA application demonstrated the ability of the technique to achieve extensive tumor cell death with hematoxylin-eosin and reduced nicotinamide adenine dinucleotide-diaphorase cell viability stains.5

Treatment options for advanced and recurrent malignancies in the head and neck region are often toxic, deforming, and threatening to patient’s speech, swallowing, and appearance. Furthermore, results of salvage attempts in terms of local control, survival, and quality of life are often poor.9 Our purpose in investigating RFA in the treatment of head and neck tumors was to explore the development of a minimally invasive modality to avoid the effects of more toxic traditional treatments.
METHODS

To date, we have applied RFA to various head and neck malignant tumors on 15 occasions in 12 patients, with an age range of 49 to 79 years (mean age, 62 years). All patients were treated using a research protocol approved by an institutional review board and a cancer care review committee. Primary RFA was applied to 12 tumors. Radiofrequency ablation was subsequently reapplied to 3 tumors that persisted or recurred after the initial application. All patients were treated with commercially available RFA devices (RITA Medical Systems Inc, Mountain View, Calif). Most patients were treated with the first-generation umbrella probe. A second-generation needle probe electrode that uses simultaneous hyperthermia and saline infusion was used in 1 case to effect a 7-cm ablation.

Certain basic precautions should be taken before RFA is applied to head and neck tumors. Protection of the eyes with a head drape, as well as careful attention to all pressure points, is essential, as with any endoscopic procedure in the head and neck region. The RFA grounding pads (similar to unipolar electrocautery grounding pads), which have a large surface area, must be carefully placed on both thighs, with the entire pad in complete contact with the skin. The RFA machine must run a self-test, and the electrical cords that go to the grounding pads and to the probe itself must be properly inserted. If an XLi needle probe is used (generally for 5- to 7-cm ablations), all active electrodes must be tested for adequate flow of saline, the saline pump must be loaded, and the rates of infusion must be set (usually 0.2 to 1 mL/min). The target temperature is set at 80 to 110°C, and the power is set at 90 to 150 W. If a percutaneous approach is planned, then a sterile technique is used.

The RFA probe is placed into the tumor, and surrounding tissues are protected using moist gauze or throat packing. A single ablation is sufficient for spherical tumors as long as the inner electrode tines reach the tumor margin in every direction. Multiple ablations may be necessary for adequate treatment of irregularly shaped tumors.

The following types of techniques were used alone or in combination to apply RFA in the 15 tumors that we treated: endoscopic (n=3), computed tomography (CT) guided (n=7), intraoperative ultrasound guided (n=3), fluoroscopically assisted (n=1), and percutaneous (n=10), and under direct vision (n=8).

Placement of the RFA probe under direct vision is appropriate for easily accessible oral cavity tumors (Figure 2). The probe tines are opened until they are seen to exit the tumor; then they are withdrawn into the tumor before energy is applied. On 2 occasions, a tumor of the base of the tongue was exposed using a Weerda supraglottiscope, through which the RFA probe was placed and deployed (Figure 3). This method offered excellent tumor visualization, and on 1 occasion, the position of the probe was confirmed by fluoroscopic imaging. Accurate placement of the RFA probe in a recurrent parapharyngeal tumor was confirmed by direct laryngoscopy using a Dedo laryngoscope.

Intraoperative ultrasound has been used, with limited success, for placement of the probe into the tongue. Although the RFA probe can be identified in the tongue with the ultrasound probe, ultrasonic differentiation of tumor from normal tongue has not been possible, and changes in the echotexture during ablation are not appreciable. However, ultrasonic identifica-
tion of the carotid artery during ablation of extensive neck metastases has proved useful.

The percutaneous approach is often desirable for optimal probe placement in certain tumor locations. The skin is painted with antiseptic solution, and the needle probe is inserted directly through the skin or through a small stab incision (Figure 4).

Placement of the RFA probe under CT guidance offers excellent tumor localization and confirmation of the initial needle placement, as well as distribution of the electrodes throughout the extent of the tumor. Multiple directed scans can be obtained until optimal placement is achieved. Postablation CT scans demonstrate immediate changes consistent with tumor destruction (Figure 5 and Figure 6).

On 3 occasions, bulky tumors of the tongue and floor of the mouth that were projecting out of the mouth before surgery were treated with RFA. Portions of the tongue were subsequently removed in the operating room to achieve complete oral competence. Since these partial glossectomies were performed on nonviable tongue tumors, no blood loss was incurred. Comparison of pathologic specimens before and after treatment showed extensive nonviable tumor tissue (Figure 7).

RESULTS

The intent of the present study was to determine the safety and feasibility of RFA for palliative treatment of head and neck tumors (Table). One objective that was accomplished in the course of the study was the development of techniques to accurately apply RFA in the head and neck region. Reasonable safety was shown in that no perioperative deaths occurred. One major complication of stroke occurred in a patient 7 days after a CT-guided RFA treatment of a recurrent oropharyngeal tumor that encased the carotid artery. She was readmitted for pneumonia 4 days after the procedure and then developed a cerebral stroke 3 days later, resulting in a moderate change in mental status and a temporary hemiparesis. Minor complications included cellulitis (n=2), postoperative pneumonia (n=1), a central venous catheter infection (n=1), enlargement of a preexisting orocutaneous fistula (n=1), and a temporary mental status change (n=2). The cellulitis, which occurred in 2 patients, both of whom underwent RFA percutaneously, resolved with antibiotic therapy.

Thirteen treatments were applied to squamous cell carcinomas in the following regions: tongue/floor of the mouth (n=5), tonsils (n=4), base of the tongue (n=2), maxillary sinus (n=1), and neck (metastatic from the floor of the mouth) (n=1). Two treatments were applied to an advanced medullary thyroid cancer in the same patient.

Formal analysis of local control, survival, and quality of life awaits maturation of data. Our study patients...
reported subjective improvement in the following areas: pain (n=9), appearance (n=3), and function (n=4). Functional improvement in 4 patients included improved ability to swallow, improved breathing through the nose, improved breathing through the throat, and relief from trismus.

Radiofrequency ablation of malignant tumors in the head and neck can be performed accurately and with a reasonable level of safety. The procedure takes less than 1 hour and requires no incision or blood loss, and the patient is often ready for discharge within 1 day. Numerous techniques, including CT, ultrasound, and fluoroscopy, have been used to guide the probe. Routes used for access include direct transoral, endoscopic, and percutaneous puncture. No perioperative deaths occurred in the present study, and other than the 1 major complication of cerebral stroke, all complications were readily managed.

Our approach has been to avoid direct puncture of the carotid artery, but not to avoid ablation of adjacent tumor. Vascular structures have generally been thought to be protected from hyperthermic techniques because the flow of blood acts as a coolant, and, indeed, it is more difficult to achieve target temperatures in perivascular regions. The patient in our series who developed a cerebral stroke 7 days after the procedure had been recovering well until then; it is therefore unlikely that the carotid artery thrombosed at the time of the procedure. Rather, an intimal injury may have been caused, or perhaps the artery wall was damaged, allowing subsequent tumor invasion and occlusion. Also, in light of the patient’s long history of heavy smoking, it is likely that she had significant arteriosclerotic disease as well. Thus, it

### Patient and Tumor Characteristics, Results, and Adjunctive Modalities

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Abbreviations: A, appearance; CS, cerebral stroke; CT, computed tomography; F, function; P, pain; US, ultrasound.
*Second treatment 15 months later.
†Second treatment 6 weeks later.

Figure 7. Biopsy specimens of tumor before (A) and after (B) radiofrequency ablation (hematoxylin-eosin, original magnification >200).
is possible that the procedure induced a subsequent thromboembolic event in an already diseased carotid artery. We have added the description of this case to our informed consent process and have adjusted our technique to decrease the ablative intensity and proximity to the carotid artery in ablations of tumors that encase the carotid artery.

Immediate palliation, including disappearance of pain, reduction of analgesic requirements, and elimination of tumor bulk, was seen in several individual cases. Three patients who had previously been unable to close their mouth because of oral tumor protrusion were able do so immediately after the procedure.

Radiofrequency ablation is a reasonably safe and feasible modality for the palliative treatment of selected advanced and recurrent head and neck tumors when no other good treatment option exists. Carefully constructed animal and clinical trials of RFA plus chemotherapy and/or radiation therapy for the treatment of recurrent tumors are under consideration for the near future.

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REFERENCES